Categorization of Suspended Particulate Matter (SPM) in Whidbey Basin

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Introduction

Suspended particulate matter (SPM) is a major factor in regulating the dispersion of pollutants and other chemicals in marine waters. The movement of SPM can indicate where pollutants and resuspended materials are being transported and deposited. SPM is controlled by biological, chemical, physical, and geological processes (Baker, 1984; Owens et al., 1997). Examining SPM for organic and inorganic materials as well as vertical distribution will provide a better understanding of these processes.

Our study area was at Department of Ecology (DOE) site PSS019, landward of Gedney Island in the southeastern portion of the Whidbey Basin (48° 1' N, 123° 18' W) (Figure 1).

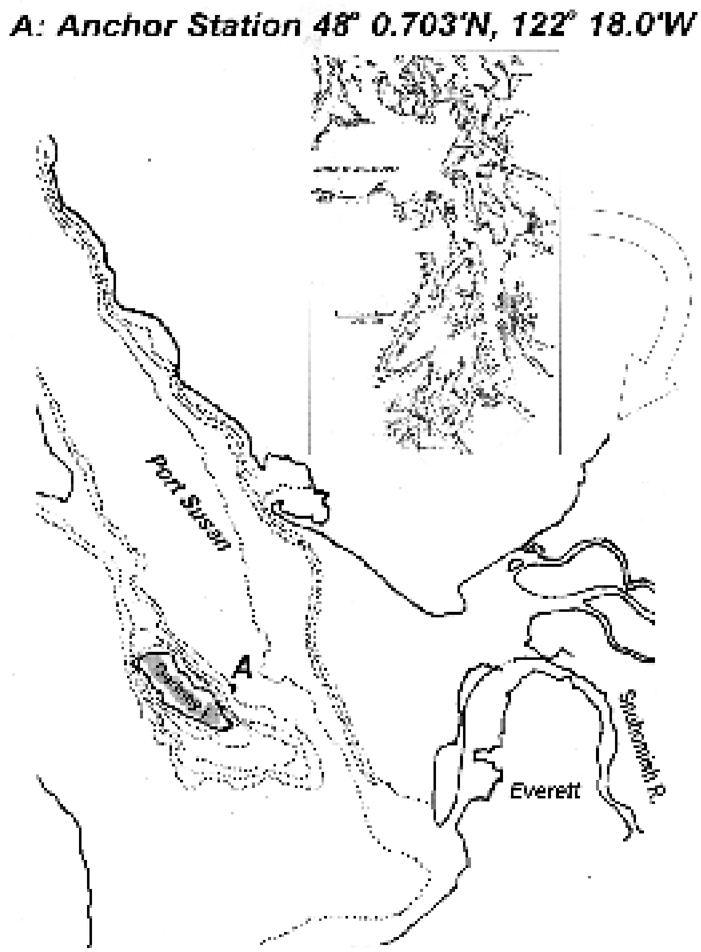


Figure 1. A map of Puget Sound with an expanded view of the study site in the Whidbey Basin. Note that there are three major rivers (Stillaguamish, Skagit, and Snohomish) emptying into this basin. A: Anchor station at 48_ 0.703' N, 122_ 18.0' W.

The site is near Everett, WA and has received little attention pertaining to SPM and other oceanographic details. SPM at this DOE site has never been examined and may prove to give valuable insight to sediment transport in the Whidbey Basin. This area is also very interesting because ~70% of the freshwater input to the Puget Sound flows through this area from the three large rivers (Skagit, Snohomish, and Stillaguamish Rivers).

Methods

From 16–18 April, 1997, water samples were collected every three hours with 12 5-liter Niskin bottles at varying depths. Sub-samples were transferred into one-liter bottles and filtered through pre-weighed 0.7-µm glass fiber filters (Whatmann GF/F). Then filters were rinsed with distilled water to remove salts. They were also examined with a dissecting scope for a qualitative description of the particulate matter. Filters were placed in prelabled Petri dishes and dried until their weight was constant. Finally, filters were moved to an oven set at 450°C for 12 hr to burn off all volatile material.

Temperature, conductivity, pressure, and percent transmission were measured electronically using a Sea-Cat CTD. These measurements were taken continuously through the water column as per the method outlined by Crone (1997). Percent transmission data was converted to absorbance in order to show a positive trend between absorbance and SPM concentrations.

Transmission data has been used in other studies to show correlation between beam transmission and SPM concentration (Baker, 1984; Wells and Kim, 1991).

Results

SPM had a maximum concentration at 0 m (approximately 4.8 mg/L), which decreased to a minimum between 30 to 60 m (Figure 2).

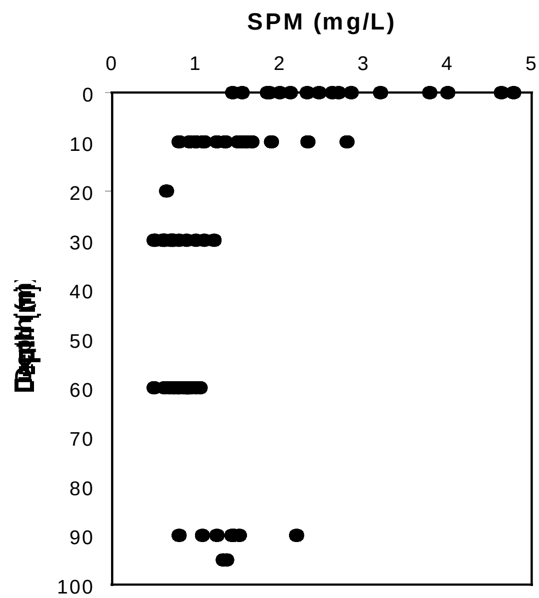


Figure 2. SPM concentration vs. depth data from discreet samples taken during study period.

Particulate organic matter (POM) followed a similar trend. However, inorganic particulate matter (IPM) had a maximum concentration at the surface decreasing to a minimum at 30 m (approximately 0.1 mg/L) and increasing at 90 m (Figure 3).

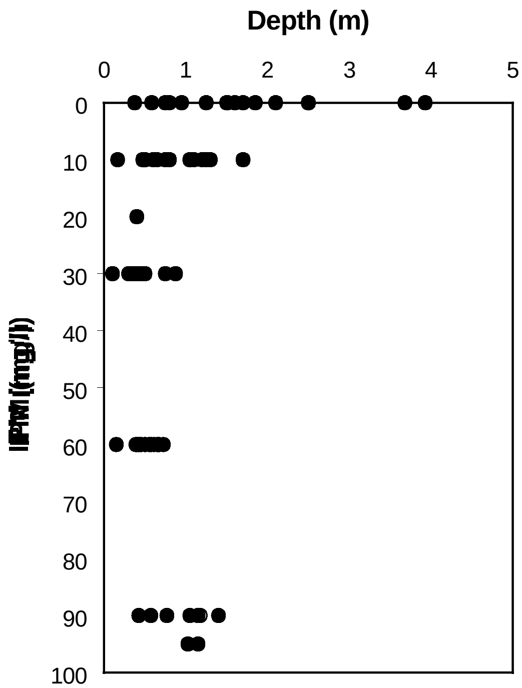


Figure 3. IPM vs. depth profile from discreet bottle samples.

POM and IPM values are in agreement with the results of the visual analysis we made of the samples prior to drying. We found phytoplankton and fecal matter to be greatest at the surface and lowest at 90 m. In the surface waters IPM was present as mud and opal from biological organisms. In 90-m samples, the IPM was observed as silt.

At surface and bottom depths the absorbance data had maximum values which correspond to SPM maximum values. When SPM and absorbance data from all casts were taken into account, no direct relationship between SPM and absorbance was found. However, in single casts a correlation was found between SPM and absorbance (Figure 4).

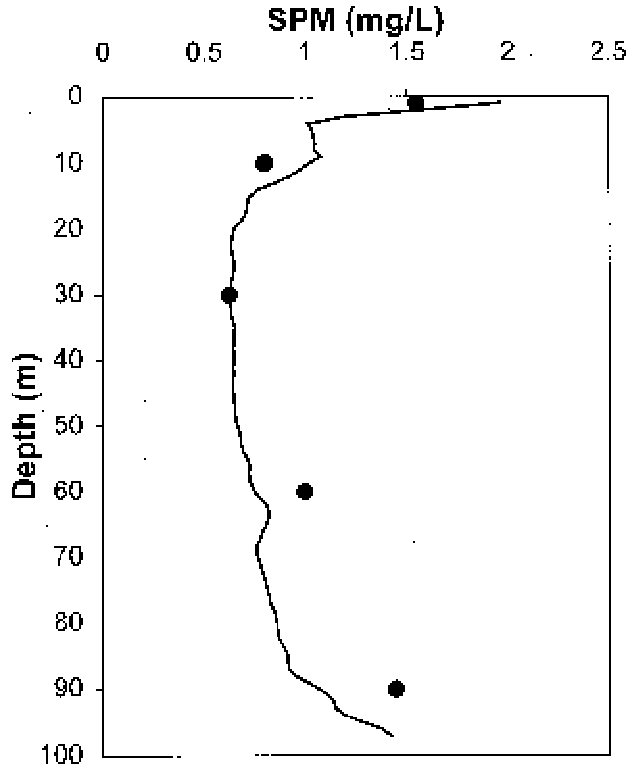
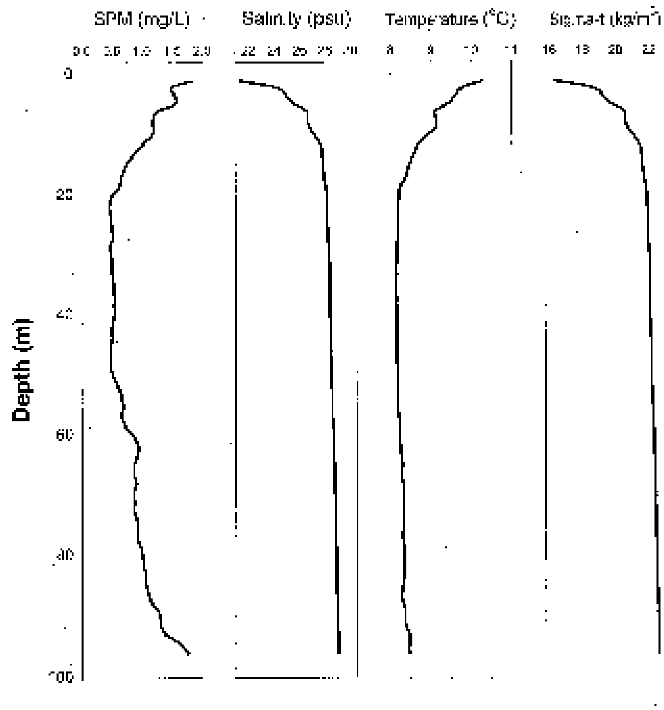


Figure 4. SPM vs. depth profile after correlating absorbance with discreet samples. This is cast 17 of 19, with r^2 of 0.65.

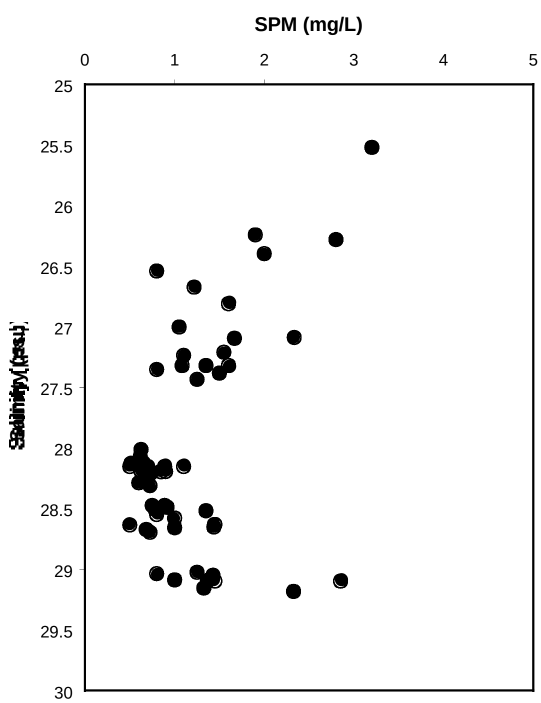
The relationship of in-cast SPM to absorbance allowed us to calculate SPM trends at continuous depths by looking at absorbance in each single cast.

Discussion

The temperature, salinity, and density vs. depth plots show three distinct water types at the study site (Figures 5a,b). The increase in density and salinity at ~10 m corresponds to the change from river influenced water to intermediate Puget Sound waters. The salty, dense, warmer bottom-water mass may be a result of intruding seawater. Finally, the mid-depth layer has increasing salinity and density and decreasing temperature with depth due to mixing of the top and bottom layers.



(a)



(b)

Figure 5(a). SPM, salinity, potential temperature, and density vs. depth for the study site. Cast 17 of 19. (b) Salinity vs. SPM. This graph shows the intruding salty bottom water as an increase in SPM with salinity after 28.5 psu.

Our findings of high levels of SPM in the top (0–10 m) and bottom (90 m) of the water column agree with other research done in the main basin of Puget Sound (Baker, 1984). Baker (1984) found high levels of light attenuation in the upper and lower layers of the water column, which corresponds to our measured high levels of absorbance. Baker also comments on a bottom nepheloid layer (BNL) which is present in the main basin of the Puget Sound (1984). Our high particle levels in the bottom waters extend this BNL into the Whidbey Basin. The BNL is the major transport mechanism of bottom sediment of the Puget Sound (Baker, 1984). Our deep water measurements were all taken at low bottom water motion (slack or near-slack tides) and were all approximately 10 m from the bottom, yet show the BNL, suggesting that it is present throughout tidal cycles.

The observed high concentrations of SPM in the upper layer may be due to several processes. Detritus and some phytoplankton and zooplankton may have a difficult time penetrating the high-density barrier between the top and mid layers. Also there is an area of no net motion between the outgoing river runoff and the incoming tidal flow (Barnes and Ebbesmeyer, 1978). The interface between the two oppositely flowing water layers may also be an area of high turbidity. The zone of high turbidity along with the strong pycnocline may act as a strong SPM capture area for low-density material. River runoff carrying sediment from the Stillaguamish, Snohomish, and Skagit Rivers emptying into the Whidbey Basin, along with opaline phytoplankton material, contribute to high IPM surface concentrations.

The percent POM and POM concentration vs. depth (Figure 6) showed interesting results. When POM concentration vs. depth was examined, a trend of relatively high concentration in the upper layer with decreasing concentrations down to the BNL can be seen. However, the trend in the percent POM indicates organically enriched SPM in the mid-depth layer.

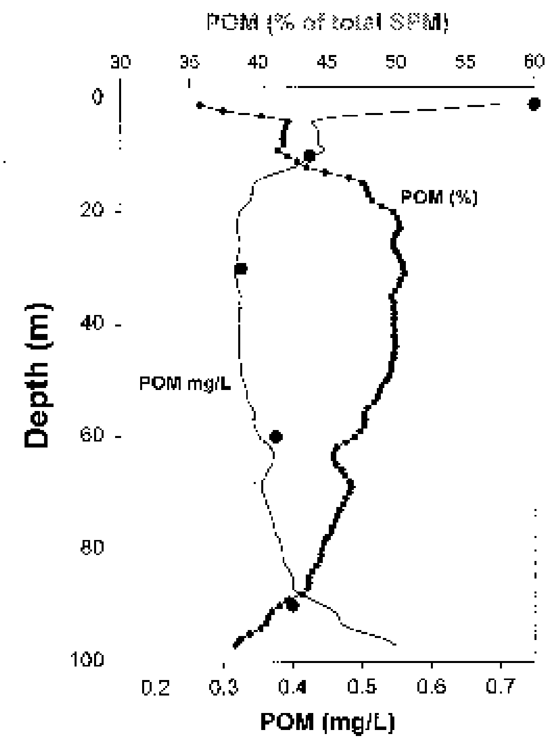


Figure 6. %POM and POM concentration vs. Depth. This graph indicates the composition of the SPM in the different layers. Lines represent POM concentration and %POM continuously through the water column. Circles represent discreet POM concentration data taken from bottles.

At the BNL, the concentrations of POM increase while percent POM decrease. The relatively low density POM has a longer residence time in the slower moving mid-depth layer while high-density IPM settle through the mid-depth layer to the bottom where it may be resuspended by the BNL.

In conclusion, SPM has three distinct layers through the water column in the Whidbey Basin. These layers have approximately the same profile and the same concentrations of that in the main basin. The surface layer (0–10 m) has a high concentration of SPM dominated by IPM. This surface layer is flowing southward and carries river debris and biological organisms out of the study area. The SPM concentrations decrease in the mid-layer where there is a high percentage of low density POM. This organically rich mid-depth layer has a zero net motion and has large residence times in this basin. The bottom layer contains a BNL, which has a high SPM concentration dominated by IPM. The BNL is a major factor in the movements of bottom sediments, and is present at all times over much of the Puget Sound (Baker, 1984). Particles are resuspended from the bottom and carried by the circulation of bottom water (Baker, 1984). Unfortunately, we were unable to obtain the direction of bottom water motion in the Whidbey Basin which would provide the direction of bottom sediment transport.

Acknowledgments

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